Mutual Affinity Between the Wagener and Jonathan Apple.

A Thesis

Presented in partial fulfilment of the requirements for the

Degree of Master of Science in Agriculture in the

Department of Horticulture

of the

University of Idaho

by

W.C. Edmundson, B.S.Agr., and E.A. Hunting, B.S. Agr.

1911.

MUTUAL AFFINITY BETWEEN THE WAGENER AND JONATHAN APPLE.

PREFACE.

***

This thesis has been done by Mr. E. A. Hunting and Mr. W. C. Edmundson in orchard number three of the Experiment Station of the University of Idaho. Owing to the inclement weather during the blossoming period, additional help was necessary to accomplish good results. This help was under the direct supervision of the authors. Mr. Veach's orchard was used in collecting Jonathan pollen, as the supply was inadequate in the Station orchards.

Up to the present time some commendable work has been done with cross-pollination of the apple, but little or no work has been accomplished along the line of mutual affinity of varieties. The object of this thesis is to determine whether the Wagener and Jonathan apples are self sterile or self fertile, and to ascertain their affinity for each other.

Within the scope of this thesis an exhaustive treatment of all sides of this subject is impossible, owing to the shortness of season in which the trees are in blossom.

From our experimental data we hope some valuable information may be obtained for the growers who are interested in growing the Wagener and Jonathan varieties.

HISTORY.

There is very little positive knowledge concerning cross-pollination of fruits, and probably no subject connected with pomology is in greater need of development. It has been only a period of a few years that the horticulturist has been able to gain any light upon this subject.

The importance of insects in cross-pollination has been touched upon by many writers. As early as 1793, C.E. Spengel, a German writer, published a book entitled "The Secret of Nature in Fertilization." In this work he clearly proved by innumerable observations how essential a part insects play in the fertilization of many plants. Herman Muller also published some interesting works on Transportation of Pollen. Probably Andrew Knight saw the truth more clearly than other early writers, for he remarks; "Nature intended that a sexual intercourse should take place between neighboring plants of the same species." He also wrote several articles on the means by which pollen is transported from flower to flower.

Darwin wrote many works on fertilization and cross-pollination of plants. His work on "Cross and Self Fertilization in the Vegetable Kingdom" takes up the ways and means of fertilization, and also the effects of cross and self fertilization. In his book on Origin of Species, he says, "With all animals and plants a cross between different varieties or between individuals of the same variety, but of a different strain, gives vigor and fertility to the offspring."

In late years many of the Agricultural Colleges of the United States have taken up this subject and have obtained

many beneficial results. M. B. Wait of the U.S. Department of Agriculture has done much to enlighten us on this important subject. F. A. Waugh, L. H. Bailey, C. P. Close, and S.W. Fletcher have performed experiments in pollination. C. I. Lewis and C. C. Vincent of the Oregon Agricultural College published a bulletin in February 1909 entitled "Pollination of the Apple" which gives us a splendid idea of the manner in which such experiments are carried on.

OBJECT.

The primary objects sought in this work were (1) to make a sterility test of the Wagener and Jonathan apple and, (2) to determine the reciprocal affinity of these varieties.

In addition to these determinations, it is hoped that we may be able to gain some knowledge of the influence which the age of pollen and the time it is applied has on its power to fertilize the blossoms.

It is evident that pollen artificially applied is obliged to perform its functions under conditions which are not entirely normal. Although every care is exercised, there is a possibility that, under such artificial conditions, one or more factors may cause the failure of the ovary to become fertilized. These factors are as follows: (1) the use of pollen which was gathered too soon or too late after it has apparently become ripe, (2) kept for too long a time after it was gathered, (3) applied at a time when the pistils were not at their highest state of receptivity, (4) pistils injured by being crowded when bagged or when the anthers were removed. Other abnormal conditions which may not occur to one not making a detailed study may enter in. This empathizes the necessity of doing the work under conditions which are comparable, or at least comparing only those results which are secured under conditions comparable.

It is further expected that this work will show something of the influence which reciprocal pollination may have on the color and quality of the fruit, but this cannot be determined till the fruit ripens, at which time the observation will be

made.

METHODS.

MATERIALS USED.- Two pound paper bags for bagging and tags for labeling blossoms were secured. Fig.No. 1 shows the equipment used which consisted of a small pair of scissors, which were used in the emasculation of blossoms, and a small viol containing a small camels hair brush and plugged with cotton, in which pollen was carried from the green house.

EMASCULATION.- The first operation in making a cross pollination is the removal of the petals from the bud a short time before it is ready to open. Figs. Nos. 2 and 3 give a good idea as to how this is done. The petals may not always be as completely removed as shown but where only a part of a petal remains intact it does not interfere with the operation which follows, that of removing the anthers. This operation is shown in Fig. No. 4. When buds worked on were ready to open the filaments bearing the anthers were found to be long enough so that they could be emasculated by simply cutting the filaments off far enough down to get all the anthers without injuring the sepals. If, however, the bud was emasculated while it still was more or less compact, the anthers were removed by catching them between the points of the partly open scissors and pulled or stripped off. After emasculating, the spur bearing the buds was labeled, showing the date of emasculation, and bagged. Fig. No. 5 shows a tree as it appeared after having been worked upon.

POLLINATION.- The first thing to be done in connection with this part of the work is to make provision for securing the pollen. As the Jonathan blooming period, this season, began nearly ten days later than that of the Wagener, it was necessary, in order to have ripe pollen when needed, to gather twigs five or six days before it was needed and take them to the greenhouse where they were placed in jars of water and allowed to blossom. Fig. 6 shows how the jars containing the twigs were covered with hoods to prevent the admixture of foreign pollen.

It was planned to get pure Wagener pollen by placing on branches bearing a large number of buds, twenty-five pound paper bags, but as a strong wind was blowing almost continually, it would have been necessary to take the branches to shelter in order that the pollen could be gathered. Hence it was found to be equally as convenient to provide pollen from the Wagener in the same way as the Jonathan pollen was secured.

It has been found that where the bud is nearly ready to open it makes little difference whether the pollen is applied at the time of emasculation or later, if done within three or four days after the operation. All of the blossoms of the Wagener, which were worked on sometime before they were ready to open, were pollinated within three or four days after they were emasculated. The larger part of the Jonathan, being nearer the blooming period when emasculated, were pollinated at that time.

There is, perhaps, a greater difference in the influence exerted by the age of the pollen than in the time it is ap-

plied to the pistils. Therefore all pollen used was collected the day before or on the same day which it was applied.

STERILITY TEST.- In conjunction with the usual method, a somewhat different method was used to make the sterility test of the Jonathan and Wagener varieties. Perhaps the most common way of making this determination is by bagging the clusters of buds before they open, to prevent fertilization from foreign pollen. Another devise that has been used to prevent fertilization from foreign pollen is that of a cage consisting of a light frame work covered with a fine cheese cloth, which is built around the tree.

With animal breeders there are certain principles of breeding, pertaining to blood relationships, which influence fecundity, such as in-and-in breeding and close breeding. It has occurred to us that it would be quite reasonable to expect fewer fertilizations to take place, when pollination is restricted to that of the same tree, than would be the case had the pollen come from another tree or even from several other trees of the same variety, which would be the case were the blossoms of the tree not isolated from natural pollination. Following out this idea, the blossoms on one tree were bagged in the usual way, while on another tree the blossoms were emasculated and pollinated with pollen taken from another tree. Pollen used to make this sterility test on the Wagener was taken from another Wagener tree (No. 261a) while that used for the Jonathan was taken from a Jonathan tree in Mr. Veach's orchard.

DATA AND RESULTS.

TABLE I.- STERILITY TESTS.

Tree No.	Var.	Emas. Or Bagged.	Pol.	Pol.Col.	No.emas. or Bagged.	Fruit Set. No.	Fruit Set. Date.
266a	Wag.	5/4	5/12	5/11	141	72	5/31
267a	Wag.	5/5	Self pollinated.		121	50	5/31
				Total . . .	262	122	
349	Jon.	5/12	5/12	5/11	15	none	5/31
369	"	5/13	5/25	5/25	40	"	5/31
349	"	5/19	5/23	5/23	15	"	5/31
369	"	5/19	5/23	5/23	20	"	5/31
358	"	5/19	5/23	5/23	30	"	5/31
342	"	5/8	Self pollinated.		135	2	5/31
				Total . . .	255	2	

TABLE 2.- WAGENER X JONATHAN.

Tree No.	Var.	Emas.	Pollen Applied.	Pollen Gathered.	No. Emas.	Fruits Set. No.	Fruits Set. Date.
265	Wag.	5/5	5/10	5/10	136	123	5/31
264a	"	5/6	5/9	5/9	150	135	5/31
265a	"	5/6	5/10	5/10	133	126	5/31
264	"	5/6	5/9	5/9	124	117	5/31
				Total	543	501	

TABLE 3.- WAGENER X JONATHAN.

343	Jon.	5/9	5/9	5/9	30	26	5/31
364	"	5/10	5/11	5/11	130	87	5/31
367	"	5/10	5/10	5/10	144	95	5/13
368	"	5/12	5/12	5/12	108	82	5/13
365	"	5/13	5/13	5/12	20	13	5/13
				Total	432	308	

The letter "a" following the numerical part of the tree number indicates the tree next south of the tree which bears the numbered tag e.g. No.267a indicates the next tree south of tree No. 267.

SUMMARY OF RESULTS FROM STERILITY TESTS AND CROSS-POLLINATION.

The conclusions which can be drawn from Tables 1, 2, and 3 are as follows:

1.- The figures in Table 1 show that the Wagener is what would be considered self fertile, as nearly one-half of the blossoms which were pollinated with their own pollen were fertilized.

2.- From figures in the same table it is evident that the Jonathan is practically self sterile, only two blossoms out of 255 having become fertilized.

3.- The results given in table 1 also shows that no better results are secured by pollinating the blossoms on one tree with pollen from another tree. The figures which are given in the last line of each division of the table are the results from the trees pollinated with their own pollen.

4.- Tables 2 and 3 contain figures which show that a mutual affinity exists between the Jonathan and Wagener apples. Jonathan pollen on Wagener blossoms seems to be more potent than Wagener pollen on Jonathan blossoms, since the former 92.26% of the blossoms pollinated set fruit while 70.13% of the latter set fruit.

5.- From the results secured in this work we are warranted in believing that it would be advisable to alternate rows of the Jonathan with rows of the Wagener to secure more perfect pollination. One row of Jonathan alternated with four or five rows of the Wagener would make perfect pollination much more certain. It is advisable, however, to have not less than 2 or 3 rows contiguous, as a single row of one variety alternating with several

rows of another variety would make the gathering of the fruit a matter of inconvenience. The proportion of the number of rows of one variety to another would of course be determined by the preference of the grower.

NATURAL INFLUENCE ON POLLINATION.

TRANSPORTATION OF POLLEN.- It has been a question with many fruit growers for some time just how pollen is transmitted from flower to flower in their orchards. It has been discovered by careful observation and numerous experiments that pollen is carried in two principal ways,-- by the action of the wind and by insects.

The majority of plants are probably fertilized by the visits of insects. Darwin says, "So necessary are the visits of bees to many of our flowers that their fertility is greatly diminished if their visits be prevented." It is practically impossible for insects to fly from flower to flower and not carry pollen from one to the other. The constructions of insect pollinated flowers is commonly more or less complicated, and differs somewhat from flowers which are pollinated in other ways. For example, the Coralla is commonly prominent and highly colored to be attractive to insects.

Many flowers are attractive to insects because of their fragrance. Flowers rich in nectar, such as the apple, are very attractive to insects.

Flowers depending on wind pollination differ from insect pollinated flowers in relative absence of attractiveness, nectar and odor. Wind pollination is common in all orchards to some extent. The pollen of wind pollinated flowers is generally light and easily carried by the wind. The influence of wind on pollination has been worked out quite thoroughly by many of the experiment stations. The oregon Agricultural College has made some interesting experiments.

EFFECT OF RAINFALL UPON POLLINATION. - The disastrous effect of excessive rainfall at bloom time upon the "setting" of fruit has long been admitted by fruit growers, but few experiments up to date have been made to prove this long accepted belief.

The New York Experiment Station has performed experiments along this line. In order to produce artificial rainfall, a Vermorel nozzel, attached to an ordinary garden hose connected with a hydrant, was used. The nozzel was thrust among the leaves of the tree and the foliage was kept decidedly moist during the greater part of the period of treatment. Part of the tree was only slightly moist. In their experiment the rainfall was kept up for twenty-five days. After the spray had been applied for three or four days, the foliage assumed gradually a sickly color and became spotted with small irregular grey spots surrounded by red borders. The petals of the flowers were effected in a similar way. At the end of twenty-one days the anthers of the innermost stamens were plump, while the outermost ones were swollen and decayed. After the spray had been removed many flowers with perfect anthers and pistils remained presumably capable of self pollination, but only one fruit bearing three seeds was produced. The unsprayed trees produced a fair crop of normal fruit.

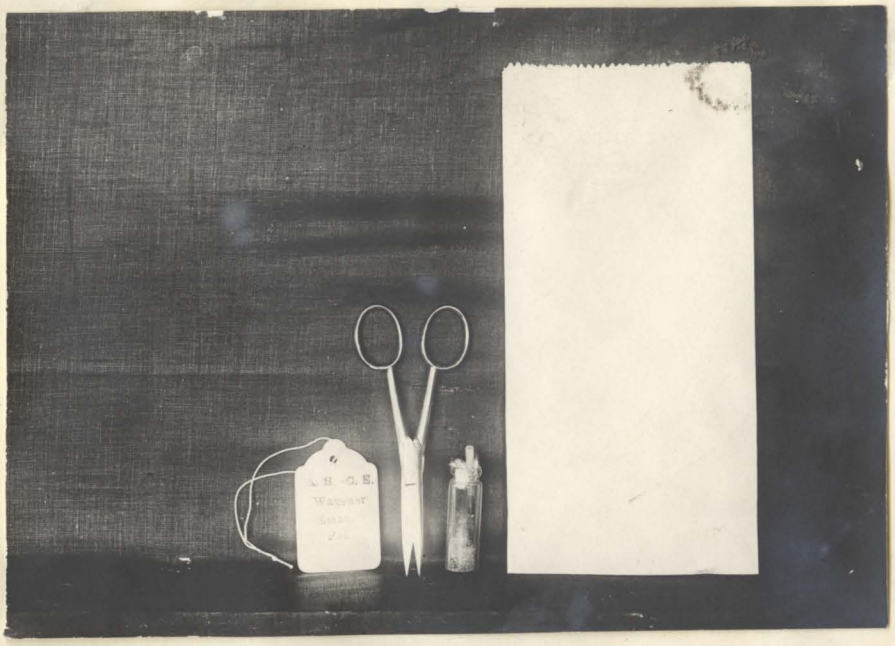

Fig.1. Equipment used in pollinating flowers. This style of label was used on all bags.

Fig.2. First step in emasculating.

Fig.3. Second step in emasculating. Removing petals.

Fig.4. Removing anthers in emasculation. Care must be taken to remove all anthers.

Fig.5. Wagener tree after pollination. Bags are removed after fruit sets.

Fig.6. Gathering pollen in greenhouse. Forcing-hoods were used to keep out foreign pollen.

Fig.7. Twig in full bloom on March 30th. Showing what can be done by forcing.

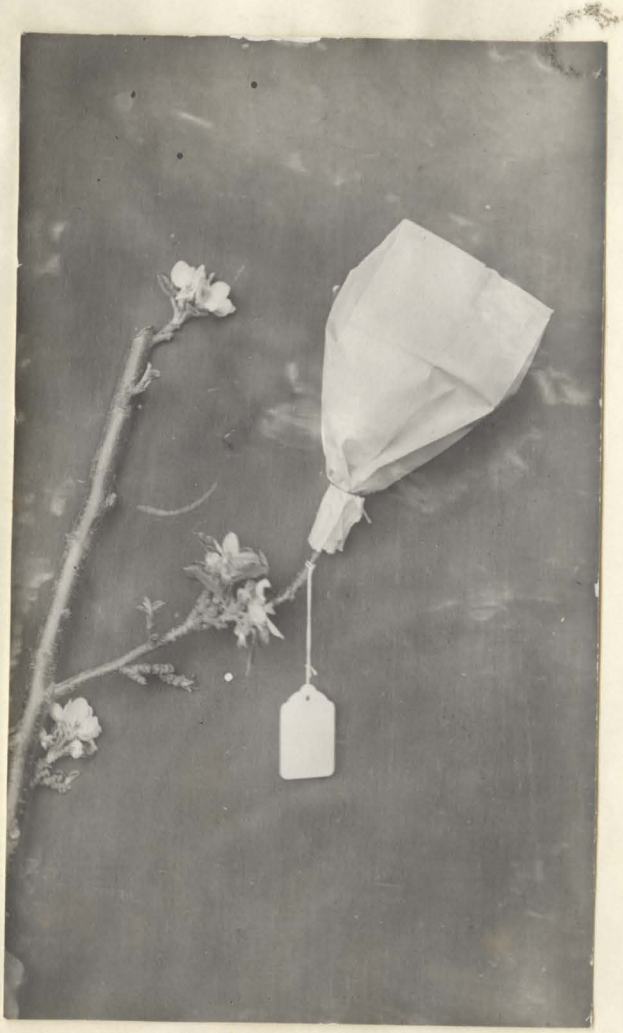

Fig.8. Blossom bagged after emasculation. Bag must be securly fastened.

Fig.9. At work pollinating blossoms. It is easier to bag blossoms on end of limbs.

Fig.10. Trees bagged after pollination.
Section of Wagener trees
used in thesis work.

BIBLIOGRAPHY.

1898, Plant Breeding, L. H. Bailey.

Annals of Horticulture, L. H. Bailey.

Knuth's Handbook of Flower Pollination, J.R. Davis, Vol.1.

Transactions, Iowa Horticultural Society, 1907, Vol. 42.

Observations on Hybrids, 1821, Thomas Knight.

Cross-breeding, 1823, Thomas Knight.

Plant Breeding and Hybridization, 1902, Hort. Soc. of N.Y. Vol. 1, pp. 257.264.

Hand Pollination of Rochard Fruits, Western Fruit Grower, Vol. 13, p. 139.

Fertilization of Apple Blossoms, Con. Hort. Vol. 26. pp. 361-363 H.S. Peart.

A lesson in Pollination, Trans. Iowa Hort. Soc., Vol. 46 pp. 372-374. C. C. Patton,

Breeding Apples in Minnesota, Proc. Ames Pomological Soc., 124-125.

Origin of Species, Pop. Science, April 1903, 841.

Effect of Rainfall upon Pollination, N.Y. Agr. Exp. Sta. Report,Vol. 19, p. 374.

Influence of foreign pollen on fruit, N.Y. Agr. Exp. Sta. Report, Vol. 5, p. 174.

New Methods of plant breeding, G. W. Oliver, U.S. Dept. of Agr., Bur. Plant Industry, Bul. 167, p. 39.

Pollination, Bessey's Botany. p. 421.

Results of Hybridization and plant breeding, Hort. Soc. of N.Y. Vol. 1. pp. 125-141, Wm. Saunders.

Breeding of Cross-bred apple for the Candaian Northwest. Rep. of Can. Exp. Farm, 6-11. Wm. Saunders.

Plant Breeding and Hybridization, Hort. Soc, of N.Y., Mem. Vol. 1, pp. 215-219. F. W. Rane.

Hand Pollination of Orchard Fruits, Proc. Internat. Conf. on plant breeding and Hybridization, 1902 Hort. Soc. of N.Y., Mem. Vol. 175-177 Price, H.C.

Plant Breeding and Hybridization, 1902, Hort. Soc. N.Y., Mem. Vol. 229-250, L.H. Pommel.

Value of Pollination in the culture of the Apple, and some of the reasons why flowers do not set. Bien. Rep. Hort. Col. 1903-1904, 212. 217. A.N. Judd.

Specific Variations due to crossing, Prog. Agr. Vol. 30, pp. 656-661

Proc. Internat. Conf. on Plant Breeding and Hybridization, 1902, Hort. Soc. N.Y. Mem. Vol.; 111-116 E. G. Hill.

Proc. Internat. Conf. on Plant Breeding and Hybridization, 1902, Hort. Soc. of N.Y., Mem. Vol. 1, 199-208. Hortley, C.P.

Breeding Hardy Fruits , S.D. Exp. Sta. Bul. 88, 1-64.

Breeding of Native Northwestern Fruits, Proc. Internat. Conf. on Plant Breeding and Hybridization, 1902, Hort. Soc. of N.Y., Mem. Vol. 1 pp. 157-158 Hansen.

Handbook on Flora Pollination, Knuth.

Proc. Internat. Conf. on Plant Breeding and Hybridization, 1902, Hort, Soc. of N.Y. Mem. Vol. 1, pp. 95-101. L.C. Corbett.

Some of the fundamental principles of Plant Breeding, Proc. Internat. Conf. on Plant Breeding and Hybridization, 1902, Hort. Soc. of N.Y., Mem. Vol. 1, 35-39

Application of some of the principles of Heredity to Plant Breeding, U.S. Dept. of Agr., Bul. No. 165.

New Methods ofPlant Breeding, U.S. Dept. of Agr., Bul. 167.

The Breeding of crossbed apples for the Canadian Northwest, W. Saunders, Canada Exp. Farm Repts., 1904, Vol. 47, pp 6-11, plts. 2.

Laboratory work in Plant Breeding, R. A. Emerson, Ann. Rpt.

Nebr. Hort. Soc. 1906, Vol. 18, pp. 277-282.

1809. Knight,Thomas Andrew. Observations on the Comparative Influence of Male and Female Parents on their Offspring. Trans. Royal Phil. Soc. 1809, pt. 1, 392; Phys. and Hort. Papers, 343.

1823. Knight,Thomas Andrew. Some remarks on the supposed Influence of the Pollen, in Cross-breeding, upon the Color of the Seed-coats of plants, and the qualities

of their fruits. Trans. Royal Hort. Soc. v. 377; Phys. and Hort. Papers, 276.

1850. Newman, John. The Influence of Parent on Offspring. Gar. Mag. vii. 341.

1852. Dutrochet. The sterility of Hybrid Plants. Gar. Mag. vii.500.

1847. Morton, S.G. Hybrid Plants. Am Journ. Sci. and Arts, 2 ser. iii. 209.

1861. Darwin, Chas. Cross-breeding in Plants. Journ. Hort. xxvi. O.s. 151.

1866. Standish, J. Hybridizing Fruits. Gar. Chron. 1866, 109. Also Gar. Month. viii. 101.

1869. Wilder, Marshall P. Remarks on Hybridization. Gar. Month. xi 3.

1872. Denny, J. The Influence of Parent on Offspring. Gar. Chron. 1872, 1263.

1873. Arnold, C. Immediate Effects of Cross-Fertilization. Gar. Month. xv. 104.

1873. Meehan, T. Influence of Pollen in Cross-Fertilization. Phila. Acad. Sci. 1873. pp. 16, 17.

1876. Bessey, C.E. Immediate Effects of Cross-Fertilization on Fruits. Gar. Month. xviii. 23.

1876. Editorial.- A New Clematis. Floral Mag. 1876, No. 59.

1876. Editorial.- Immediate Effects of Cross-Fertilization on Fruits. Gar. Month. xviii.23

1876. Grieve, P. Influence of Foreign Pollen on the Progeny of Plants. Gar. Chron. v. 699; vi. 49.

1876. Meehan, T. Are Insects a Meterial Aid in Fertilization? Gar. x. pp. 493-494. See. also 1875.

1877. Henslow, Geo. The Fertilization of Plants. Gar. Chron. vii. pp. 42, 139, 203, 270, 336, 560.

1878. Beal, W.J. Cross-Breeding of Fruits. Rep. Mich. Pom. Soc. 1878, 51.

1883. B.J.C. Effects of Cross-Fertilization on Fruit. Gar. Month. xxv. 274.

1884. Garfield,C.W. Influence of Pollen. Mich Hort. Soc.246.

1888. Goff, E.S. The Influence of Cross-Fertilizations. Rep. N.Y. Exp. Sta. iv. 184.

1887. Burrill, T.J. Notes on Crossing. Annual Hort. Rep. in Rep. Bd. Trustees Univ. Ill. xiv.

1887. Crozier,A.A. Influence of Cross-Fertilization on the Fruit. Rep. U.S. Dept. Agr. 512.

1887. Thorpe,John. Hybridizing and Cross-Fertilization. Journ. Hort. v. 521, 569.

1889. "Calyspso." Progress in Hybridizing Orchards. Gar. and Forest, ii. 367.

1891. Natural Devices for Cross-Fertilization. Pop. Sci. News, Dec. 1891, p. 772.

1891. Phelps,Lyman. Effect of Cross-Fertilization as effecting Value of Citrus Fruits. Proc. Am. Pom. Soc. 1891, 54.

1892. Bailey,L.H. Cross-Breeding and Hybridizing. New York Rural Lib. vol. i, No. 6, p.44.

1893. Craig,John. Crossing and Hybridizing. 36th Annual Rep. of Hort. Soc. of Mo. 92.

1896. Smith,Elmer D. Cross Fertilization. Rep. Mich. Hort. Soc. for 1896. 39.

1897. Coates,L. Cross-Fertilization. Cal. Fruit Grower, xx. 6.

1900. Webber,H.J. The Influence of Pollen on the Fruit of the Current Year. Report of the 321st meeting of the Biological Soc. of Washington. Science, April.

Breeding Apples for India. J.A. Burton, Amer. Breeders Assoc. Proc. 4, 1908, pp. 43-44.

Pollination of the Apple, C. I. Lewis, C.C. Vincent, Oregon Sta. Bul. 104, pp. 3-40, fig. 14.

Hybridization in Horticulture, C. Bellair.

Hybridization in Horticulture, Parvis, 1909. pp. 6-339.

Observation on Hybrids, 1821, Thomas Knight.

Cross Breeding, 1823, Thomas Knight.

Some Possibilities, Proc. Internat. Conf. on Plant Breeding and Hybridization 1902, Hort. Soc. of N.Y. Mem. Vol. 1. pp 257-264.

Hand Pollination of Orchard Fruits. Western Fruit Grower, Vol. 13, 139.

Fertilization of Apple Blossoms, Can. Hort. Vol. 25 1, pp. 261-374, H.S. Peart.

A lesson in Pollination, Trans. Iowa Hort. Soc., Vol. 46 pp. 372-374. C.C. Patton.

Breeding Apples in Minnesota, Proc. Amer. Pomol. Soc., 124-125, W. Elliott.

Origin of Species, Pop. Sci., April, 1903, 481, De Vries Hugo.

I N D E X.